



IEEE Standard for Protocols and Interfaces of Digital Retina Systems

IEEE Computer Society

Developed by the
Data Compression Standard Committee

IEEE Std 3161.9™-2023

STANDARDS

IEEE Standard for Protocols and Interfaces of Digital Retina Systems

Developed by the

Data Compression Standard Committee
of the
IEEE Computer Society

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Abstract: Specified in this standard are the aspects of communication process, general requirements, and data format of interfaces for multiple data streams and control commands involved in digital retina systems (DRSs). It provides protocol and interface specifications for the design, development, and manufacturing of devices or platforms to enable connections and interactions among heterogeneous devices.

Keywords: communication process, control command, digital retina system, feature stream, function definition, IEEE 3161.9, interface, model stream, protocol, video stream

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Introduction

This introduction is not part of IEEE Std 3161.9-2023, IEEE Standard for Protocols and Interfaces of Digital Retina Systems.

Conventional video surveillance systems commonly deal only with the video stream, which is known as one-camera-one-stream framework. However, with the rapid growth of visual data, this framework cannot efficiently support big data analysis and retrieval due to several difficulties, such as gathering massive data and the low efficiency and accuracy of data analysis.

A digital retina system (DRS) uses a one-camera-three-streams framework in which multiple data streams (video, feature, and model streams), together with control commands, are generated and transmitted in parallel to support efficient analysis and processing of massive visual data. Currently, there are no existing standards that can satisfy the data and command transmission requirements for such a framework. Therefore, the standardization of DRS protocols and interfaces is essential to enable connections and interactions among multi-source heterogeneous end-devices, edge-servers, and cloud-centers in the system. Concretely, this standard provides a protocol framework and general requirements for establishing and maintaining communication connections among subsystems. It also provides the transmission specifications of control flow and multiple data streams, and other typical processes and interfaces between subsystems under the architecture of DRS defined in IEEE Std 3161TM-2022.

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IEEE Standard for Protocols and Interfaces of Digital Retina Systems

1. Overview

1.1 Scope

This standard defines communication protocol and data interfaces for the control flow and multiple data streams in the digital retina system (DRS) with an end-edge-cloud coordinative visual computing architecture.

1.2 Purpose

The protocols and interfaces for DRS specified in this standard are based on the reference architecture defined in IEEE Std 3161™-2022.⁶ These two parts provide the structure and base content of the DRS series standards, and provide basic technical specifications to support the design, device research and development (R&D), and production of DRS. The purpose of this standard is to facilitate the interaction between multi-source heterogeneous devices and support coordinative work of end, edge, and cloud. The target applications and services include but are not limited to smart transportation, public safety, health care, and smart city.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{7,8}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

⁶Information on references can be found in [Clause 2](#).

⁷The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

⁸The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 3161™-2022, IEEE Standard for Digital Retina Systems.^{9,10}

IETF RFC 2616, Hypertext Transfer Protocol—HTTP/1.1.¹¹

IETF RFC 2818, HTTP Over TLS.

IETF RFC 3261, SIP: Session Initiation Protocol.

IETF RFC 3339, Date and Time on the Internet: Timestamps.

IETF RFC 3550, RTP: A Transport Protocol for Real-Time Applications.

IETF RFC 4571, Framing Real-Time Transport Protocol (RTP) and RTP Control Protocol (RTCP) Packets Over Connection-Oriented Transport.

ITU-T H.626V2, Architectural requirements for a video surveillance system.¹²

ITU-T H.627V2, Signaling and protocols for a video surveillance system.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. Additionally, the terms and definitions given in IEEE Std 3161™-2022 are applicable. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.¹³

No terms and definitions are listed in this standard.

3.2 Acronyms and abbreviations

DRS	digital retina system
HMAC-SHA	Keyed-Hash Message Authentication Code using Secure Hash Algorithm
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol over Secure Socket Layer
ID	identification
IP	Internet Protocol

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¹¹RFC documents are available through the IETF at <https://www.ietf.org/standards/rfcs/>.

¹²ITU-T publications are available from the International Telecommunications Union (<https://www.itu.int/>).

¹³*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

JSON	JavaScript Object Notation
JWT	JavaScript Object Notation (JSON) web token
NTP	Network Time Protocol
REST	Representational State Transfer
RTCP	Real-time Transport Control Protocol
RTMP	Real Time Messaging Protocol
RTP	Real-time Transport Protocol
RTSP	Real Time Streaming Protocol
SIP	Session Initiation Protocol
SSL	Secure Sockets Layer
TLS	Transport Layer Security
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
UTC	Coordinated Universal Time
WSS	Web Socket Secure

4. Communication process

4.1 General requirements

The reference architecture of the digital retina system (DRS) is shown in 4.2 of IEEE Std 3161-2022, and the functional requirements are defined in Clause 5 of IEEE Std 3161-2022. Based on the architecture and functional requirements, the communication process of DRS is designed to include login authentication and logout, configuration delivery, function definition, algorithm model push and pull, feature stream and video stream transmission, control command delivery, and fetching of videos, images, algorithm results, etc. Described below are the communication-related functions and corresponding communication processes of the end, edge, and cloud subsystems in detail.

The communication functions of the end subsystem of the DRS are defined in [Table 1](#).

Table 1—List of communication functions of end subsystem

Function	Description
Supporting video coding data push	The end subsystem pushes the encoded video to the edge or cloud subsystem (see 4.6)
Supporting the output of features and results	The end subsystem outputs the feature and result data according to the function definition commands delivered by the edge or cloud subsystem (see 4.4)
Supporting the push of feature and result streams	The end subsystem pushes the feature and result streams to the designated address according to the function definition commands delivered by the edge or cloud subsystem (see 4.6)
Supporting the device status reporting and receiving the status query command	The end subsystem reports or responds to the edge or cloud subsystem with its operating status (see 4.7)
Supporting the real-time reporting of temporal and spatial information of the device	The end subsystem reports the temporal and spatial information to the edge or cloud subsystem in real time (see 4.7)
Supporting the receiving of device shutdown, device restart, and device control commands	The end subsystem receives device shutdown, device restart, and other device control commands (such as adjustment of focal length or angle of camera) from the edge or cloud subsystem (see 4.8)

Table continues



Table 1—List of communication functions of end subsystem (continued)

Function	Description
Supporting the receiving of configuration parameters delivered by the edge and cloud subsystems, such as video coding format and resolution	The end subsystem receives configuration delivery commands from the edge or cloud subsystem (see 4.3)
Supporting the synchronization mechanism of features, analysis results, and videos (optional)	The video, feature, and result data transmitted by the end subsystem include unified synchronization information (see 4.6)
Supporting time synchronization with edge and cloud subsystems	The end, edge, and cloud subsystems support time synchronization through such ways as NTP services
Supporting the updating of algorithms and models delivered by the edge and cloud subsystems	The end subsystem receives and processes the algorithm model updating command from the edge or cloud subsystem (see 4.5)
Supporting the full and incremental model updating (optional)	The end subsystem receives and processes full or incremental model updating commands from the edge or cloud subsystem (see 4.5)
Supporting the dynamic deployment of algorithms and models (optional)	The end subsystem receives and processes the algorithm model updating command from the edge or cloud subsystem to implement the dynamic deployment of algorithm models (see 4.5)
Supporting the receiving and processing of function definition command	The end subsystem receives the function definition command from the edge or cloud subsystem and supports the configuration of device functions and outputs (one or more of video streams, feature data, and analysis results) according to the specified parameters (see 4.4)

The communication functions of the edge subsystem of the DRS are defined in Table 2.

Table 2—List of communication functions of edge subsystem

Function	Description
Supporting the delivery of control commands, algorithm models, function definitions, and other commands of the end subsystem	The edge subsystem sends control commands, algorithm models, function definitions, and other commands to the end subsystem (see 4.3, 4.4, 4.5, and 4.8)
Supporting the forwarding of unified temporal-spatial identification (ID), device status, and other information	The edge subsystem forward the temporal-spatial ID, device status, and other information reported by the end subsystem to the cloud subsystem (see 4.7)
Supporting videos fetching on demand	The edge subsystem receives and processes the command of videos fetching on demand initiated by the cloud subsystem (see 4.9)
Supporting the video transmission	The edge subsystem supports the receiving and push of video data (see 4.6)
Supporting the secure data sharing and interaction	All communications of the edge subsystem are based on authentication and encryption (see 4.2)
Supporting the push or forwarding of feature stream and result stream	The edge subsystem outputs the feature and result data to the designated address (see 4.6)
Supporting the algorithm model pull (optional)	The edge subsystem pulls the algorithm model from the cloud, or the end subsystem pulls the algorithm model from the edge subsystem (see 4.5)

The communication functions of the cloud subsystem of the DRS are defined in Table 3.

Table 3—List of communication functions of cloud subsystem

Function	Description
Supporting the status query of all end, edge, and cloud subsystems in the system and receiving status information	The cloud subsystem supports querying and receiving the status information of all subsystems (see 4.7)
Supporting the function definition and task distribution of the end or edge subsystem	The cloud subsystem sends function definition commands to the end or edge subsystem (see 4.4)
Supporting the delivery of device control, algorithm model updating, function definition, and other commands	The cloud subsystem sends device control, parameter configuration, algorithm model updating, function definition, and other commands (see 4.3, 4.4, 4.5, and 4.8)
Having a security detection and authority authentication mechanism among end, edge, and cloud subsystems	The cloud subsystem supports device login and authentication for edge and end subsystems (see 4.2)
Supporting the receiving and processing of video stream	The cloud subsystem supports the receiving and processing of video streams (see 4.3, 4.6)
Supporting video/image/feature/analysis results fetching on demand	The cloud subsystem supports the delivery of commands of fetching on demand and receives corresponding video, image, feature, analysis results, and other data (see 4.9)
Supporting the secure data sharing and interaction	All communications of the cloud subsystem are based on authentication and encryption (see 4.2)
Supporting the receiving of feature and result streams	The cloud subsystem receives the feature stream and result stream from the end or edge subsystem (see 4.6)

4.2 Login authentication and logout

The Hypertext Transfer Protocol over Secure Socket Layer (HTTPS) shall be used for uploading data in the DRS and the specific contents shall conform to relevant provisions as specified in IETF RFC 2818. The Web Socket Secure (WSS) protocol shall be used for command delivery. See 5.1.2 and 5.1.3, respectively.

The login authentication process is shown in Figure 1. First, the user initiates an HTTPS login request, carrying login information and device information (including device type, platform, and other details); the service provider authenticates the login request and records relevant information, followed by generating a TOKEN and returning it to the user. The user keeps the TOKEN that will be used in all subsequent HTTPS communication. After the HTTPS connection, the user initiates a WSS connection request with the TOKEN information. The WSS connection will be subsequently used for the service provider to deliver commands.

The logout process is similar to the login process. The user shall first send a logout request through HTTPS. After receiving the correct return from the service provider, the user disconnects WSS and then disconnects HTTPS.